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(54) A radio receiver.

(57) A satellite navigation receiver uses common dual-conversion superheterodyne and frequency synthesiser circuitry for receiving signals from both the GPS and the GLONASS satellite navigation systems. Successive first and second frequency down-converters (14,18) in the receiver chain are fed by first and second local oscillator signals (24,26) which are both variable in frequency such that the frequency of the first local oscillator signal (24) is an integral multiple (preferably 8) of the second local oscillator signal (26). This relationship is provided by a binary divider (32) at least a portion of which may form part of a digital frequency synthesiser loop (30).

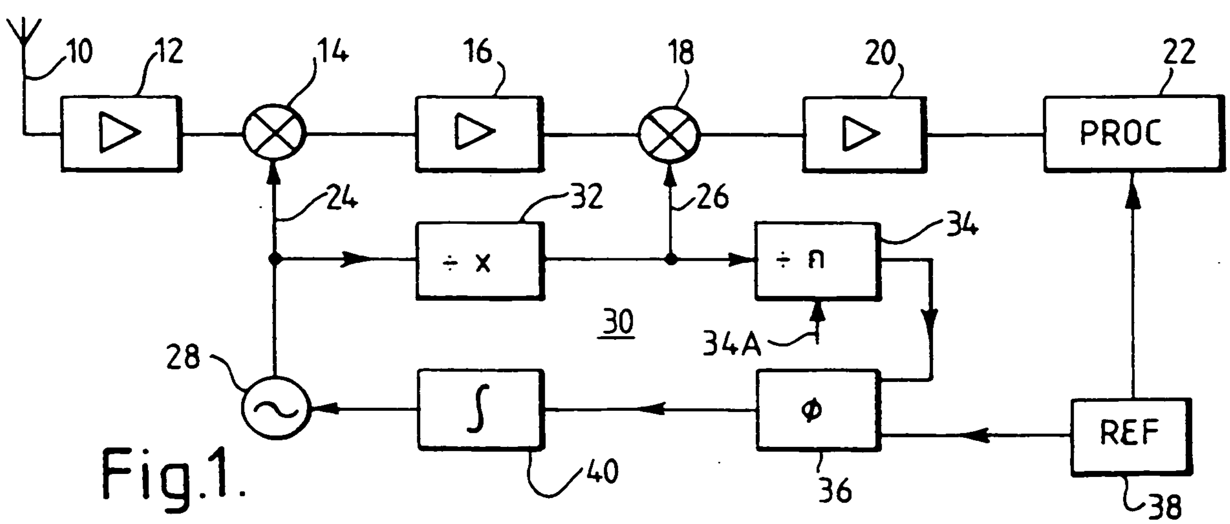

Fig.1.

respectively on lines 24 and 26, the source of the first local oscillator signal being a voltage controlled oscillator (VCO) 28 forming part of a frequency synthesiser loop 30. Control of the VCO frequency is established in conventional manner by means of a digital frequency divider chain 32, 34 feeding a phase comparator 36 which also receives a reference signal derived from a reference frequency source 38. The output of the phase comparator 36 is integrated in a low-pass filter stage 40 and applied to the control voltage input of the VCO 28.

In the present case the divider chain includes, firstly, a fixed divider 32 which acts as a prescaler for dividing the VCO frequency by a constant integer X and, secondly, a variable divider 34 for further division by a variable number n according to settings signalled via control input 34A. Coupled to the output of the fixed divider 32 is the local oscillator input of the second mixer 18 so that the second local oscillator frequency f_{LO2} is equal to f_{LO1} divided by X, X being 8 in this example.

The GLONASS satellite navigation system currently transmits signals on 24 channels between 1602.5625 MHz and 1615.5000 MHz separated by increments of 0.5625 MHz. These are often referred to as the GLONASS "L1" channels, 24 out of 32 channel allocations actually being used at present.

Conventionally, in a single loop frequency synthesiser for a receiver receiving such signals, a comparison frequency (at the phase comparator) of 0.5625 MHz might be chosen to allow switching between channels by altering the division ratio of the variable divider in increments of 1, and to give adequate synthesiser response speed and noise performance. However, such a comparison frequency cannot be obtained by direct division from a reference crystal oscillator running at 10 MHz, 20 MHz or, perhaps, 40 MHz. These frequencies are convenient for use in GPS satellite navigation receivers due to the speed requirements of the processing circuitry and the ease with which a calendar time reference can be generated for predictive acquisition of satellite signals. Indeed, stages such as frequency multipliers or non-linear mixers are required, together with filters for blocking unwanted frequency components, which are expensive in relation to dividers and, in the case of filters particularly, are difficult to incorporate in integrated circuit devices.

Instead, the receiver of Figure 1 uses a comparison frequency of 62.5 KHz, which is the highest common factor of 10 MHz and the channel spacing 0.5625 MHz. By selecting a division ratio of 8 for the fixed divider 32 and taking the output of that fixed divider as the local oscillator input for the second mixer, it will be seen that the receiver can be tuned to the 24 GLONASS channels by altering the division ratio n of the variable divider 34 in steps of 1, and by dividing the reference frequency 10 MHz in a reference divider (not shown in Figure 1) by 160, i.e without frequency multipliers or other complex components.

In terms of precise frequencies and division ratios, the frequency synthesiser may be arranged to produce first and second local oscillator frequencies of 1402.0 MHz and 175.25 MHz respectively to receive channel 1 (1602.5625 MHz), yielding a first i.f of 200.5625 MHz and a second i.f of 25.3125 MHz. The division ratio n is 2804. Changing the division ratio n to 2827 produces first and second local oscillator frequencies of 1413.5 MHz and 176.6875 MHz for receiving channel 24 (1615.5000 MHz). The second i.f remains constant at 25.3125 MHz. It will be noted now that the first i.f has changed to 202.0000 MHz. In fact, as the receiver is tuned from channel to channel, the first i.f frequency changes in steps of 62.5 KHz together with the second local oscillator frequency. A change of first i.f frequency of this order is acceptable and can be accommodated within the first i.f filter bandwidth. It will also be noted that the first local oscillator frequency is incremented in steps of 0.5 MHz, i.e 8 times the increments of the second local oscillator frequency and one 20th of a reference oscillator frequency of 10 MHz.

The above example uses local oscillator signals having frequencies which are lower than the input and first i.f frequencies respectively. Arrangements of one higher and one lower or two higher frequencies are also possible, still using the same division ratio between the two local oscillator frequencies. In other words, the relationship $X = (\Delta f/\Delta f_{LO2}) - 1$ holds true in each case.

It is possible, within the scope of the invention to choose common factors of the channel spacing and the reference oscillator frequency which are not the highest common factor. Thus, for example, the second local oscillator frequency may be incremented in steps of 31.25 KHz or 20.8333 KHz, with X equal to 17 or 26 respectively. However, these result in lower comparison frequencies, which has disadvantages as will become clear below.

By appropriate selection of a fixed value for the variable division ratio n, by switching in a different first i.f filter, by alteration of the comparison frequency, if required, and by changing the division ratio of the reference divider in the reference frequency source 38, the receiver of Figure 1 can be used to receive GPS signals on the GPS L1 frequency of 1575.42 MHz.

The receiver described above with reference to Figure 1 does have the disadvantage that the comparison frequency may not be sufficiently high to avoid limiting synthesiser switching speed undesirably. A higher comparison frequency is also preferable for reducing noise in the synthesiser loop, since loop noise is related to the ratio of the VCO frequency (the first local oscillator frequency) and the comparison frequency.

However, it is possible to trade the bandwidth of

the reference oscillator frequency.

3. A receiver according to claim 2, characterised in that the factor is the highest common factor of the frequency spacing and the reference oscillator frequency.

4. A receiver according to claim 2 or claim 3, characterised in that the first and second local oscillator sources are constituted by the frequency synthesiser, the synthesiser having a digital frequency divider, which has an input associated with the first said source and an output forming the second said source.

5. A receiver according to claim 4, characterised in that the frequency divider, in at least one mode of the receiver, is a fixed division ratio divider associated with a variable divider chain linking (a) a variable frequency oscillator having an input for variation of its frequency, and (b) a phase or frequency comparator for comparing an output signal of the divider chain with a reference signal the frequency of which is governed by the reference oscillator.

6. A receiver according to claim 4 or claim 5, characterised in that the said digital frequency divider comprises a binary divider.

7. A receiver according to any preceding claim, having two frequency down-converters, characterised in that the integer X is equal to 8.

8. A receiver according to any of claims 2 to 7, having two frequency down-converters characterised in that the integer X is equal to 8 and the reference oscillator frequency is 10 MHz or a multiple of 10 MHz.

9. A receiver according to claim 4, characterised in that the said digital frequency divider comprises first and second binary divider portions connected in series and having division ratios of 2^p and 2^q respectively, where p and q are integers and $p + q = 3$ in at least one mode of the receiver, and in that the frequency synthesiser further includes a variable divider having an input coupled to the output of the first divider portion, a reference frequency source, a phase or frequency comparator having one input coupled to an output of the variable divider and another input coupled to the reference frequency source, and a variable frequency oscillator coupled to an output of the comparator.

10. A receiver according to claim 9, characterised in that the reference frequency source includes a reference frequency divider, the receiver further including mode switching means associated with the reference frequency divider and the variable divider for allowing configuration of the receiver either as a fixed frequency receiver with a fixed synthesiser loop division ratio and with first reference and comparison frequencies, or as a variable frequency receiver with a variable synthesiser loop division ratio and with second reference and comparison frequencies.

11. A satellite navigation receiver according to any preceding claim.

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EUROPEAN SEARCH REPORT

Application Number
EP 92 30 6399

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X A	EP-A-0 430 364 (MAGNAVOX GOVERNMENT AND INDUSTRIAL ELECTRONICS COMPANY) * column 6, line 14 - line 43; figure 1 *	1,7,11 4	H03D7/16 G01S5/14
X	EP-A-0 351 156 (ASHTECH TELESIS, INC.) * column 6, line 4 - line 50; figures 1,2 *	1,7,11	
X	EP-A-0 417 682 (ALCATEL ASPACE) * column 5, line 30 - line 45; figure 2 *	1	
A	US-A-4 521 916 (WINE) * column 4, line 34 - line 43; figure 1 *	2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H03D
G01S
H03J
H03L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 OCTOBER 1992	PEETERS M.M.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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